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Effect of balanced fertilization on production, quality, energy use efficiency of baby corn (*Zea mays*) and soil health

RAKESH KUMAR[1], J S BOHRA[2], NARENDRA KUMAWAT[3], PRAVIN KUMAR UPADHYAY[4] and A K SINGH[5]

Institute of Agricultural Sciences, Banaras Hindu University, Uttar Pradesh 221 005

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ABSTRACT

Field experiment was conducted on baby corn (*Zea mays* L.) in sandy loam soil during the pre-*kharif* season of 2012 and 2013 at Varanasi to assess the effect of balanced fertilization (NPKS and Zn) on productivity, quality, energetics and soil health of baby corn. Results revealed that application of 125% RDF (187.5, 93.75, 75.0 kg NPK/ha) produced significantly higher yields of total baby cob yield with husk (9.55 tonnes/ha) and total baby corn yield without husk (2.15 tonnes/ha). Similarly, the higher nutrients (NPKS) and protein content in baby corn and green husk were recorded with application of 125% RDF. Among different levels of S and Zn, application of 50 kg S and 10 kg Zn/ha produced significantly higher yields of total baby cob with husk (9.38 and 9.24 tonnes/ha) and total baby corn without husk (2.15 and 2.10 tonnes/ha), respectively. Further, the crop fertilized with 50 kg S and 10 kg Zn/ha increased the nutrients (NPKSZn) and protein contents in babycorn and green husk but it was noted being on a par with application of 25 kg S and 5 kg Zn/ha. In terms of energetics, the higher values of energy inputs (20.71×10^3 MJ/ha), energy returns (226.98×10^3 MJ/ha), net energy returns (205.98×10^3 MJ/ha), energy use efficiency (10.80), energy productivity (0.454/kg/MJ), human profitability (65.20), energy productivity (9.80), energy intensiveness (0.354 MJ/₹), energy output efficiency (3.78×10^3MJ/ha/day) and energy intensity in economic terms (3.82 MJ/₹) were recorded with application of 125% RDF and the lowest with 100% RDF. Similarly, application of 50 kg S and 10 kg Zn/ha gave the highest values of energy inputs (18.33 and 17.91×10^3 MJ/ha), energy returns (223.12 and 219.69×10^3 MJ/ha), net energy returns (203.31and 200.09×10^3 MJ/ha), energy use efficiency (11.25 and 11.19), energy productivity (0.473 and 0.471 kg/MJ), energy intensiveness (0.330 and 0.328 MJ/₹), energy output efficiency (3.72 and 3.66×10^3 MJ/ha/day), energy intensity in economic terms (3.71 and 3.67 MJ/₹), human energy profitability (64.09 and 63.11) and energy profitability (10.25 and 10.19), respectively as compared to its preceding doses. The highest actual loss of S and Zn were recorded with application of 125% RDF, 50 kg S and 10 kg Zn/ha, whereas, the maximum positive balance of S and Zn were associated with 50 kg S and 10 kg Zn/ha, respectively.

Key words: Balance sheet, Baby cob and corn, Energetics, Nutrient content, Sulphur, Zinc

In Indian agriculture, the newly introduced crop, baby corn assumes the special significance on account of its utilization as food, feed and fodder besides the several industrial uses. Diversified uses of maize for starch industry, oil production, baby corn, pop corn and its potential for exports has added to the demand of maize all over the world besides, the other commercial avenues. For diversification and value addition of maize as well as growth of food processing industry, the growing maize for vegetable purpose, which is known as baby corn is contemplated. Baby corn is an immature, unfertilized, dehusked maize ear, harvested within 2-3 days of silk emergence (Neupane *et al.* 2011). Being a short duration crop (60-70 days), it can be sown and harvested 3-4 times in a year (Kumar *et al*. 2015). After harvest of babies, economic potential is further enhanced, since it supplies green, soft, succulent, nutritious and palatable fodder with the higher digestibility. With respect to the nutritive values, 100 g of baby corn are found to be rich in 89.1% moisture, 1.9 g protein, 0.2 g fat, 0.06 g ash, 8.2 mg carbohydrate, 28 mg calcium, 86 mg phosphorus and 11 mg ascorbic acid (Thavaprakaash *et al*. 2005). In indo-Gangetic plains (IGPs) of India, where the rice-wheat cropping system is a prominent, the cultivation of summer mungbean is recommended practices, which has

[1]Scientist (Agronomy), Division of Crop Research, ICAR RC for Eastern Region Patna, Bihar 800 014 (email :rakeshbhu08@gmail.com). [2]Professor-cum-Senior Agronomist, Department of Agronomy, Institute of Agricultural Sciences, BHU, Varanasi 221 005 (e mail: jsbohra2005@ rediffmail.com). [3]AICRP on Maize, Zonal Agricultural Research Station, Jhabua 457 661 MP (e mail: kumawatandy@gmail.com). [4]Scientist (e-mail: pravin.ndu@gmail.com). Division of Agronomy, ICAR IARI, New Delhi 110 012. [5]Assistant Professor, Department of Agronomy, Barkachcha Campus, Institute of Agricultural Sciences, BHU, Varanasi 221 005 (e mail: aamiteshbhu82@ gmail.com).

been reported non-remunerative, when planted beyond the 10 April (Singh *et al.* 2010). The pre-*kharif* season period (15 April-15 July), if put under the cultivation of short duration vegetables like babycorn, it will not cause any problem to the rice-wheat system and the same time, it diversified the system too. Baby corn is a nutrient exhaustive crop and due to high planting density, the balanced fertilization is important to realize the maximum productivity, quality, and energy use efficiency as well sustaining the soil health. As it is harvested within 1-2 days after silking, much before maturity of grain formation, the requirement of nutrition levels need to be standardized for realizing higher production potential of this crop, so that it could be popularized among the farmers.

Energy is the basic need of human life and mainstay of our national economy. India needs a total energy of ~2 billion calories to feed its alarmingly increasing population of 1000 million for production of > 200 milliontonnes of food grain by 2000 AD (Mittal and Dhawan 1988). Solutions for energy crises are slightly dependent on technology of low energy use. Era of cheap energy is now ending and population is becoming energy consumption conscious, due to the rising cost of energy. Energy use in crop production has not been given adequate importance in earlier years, but the time has come, where the more focus is to be given on renewable and non-commercial source of energy, which is actively involved in crop production processes using the intensive energies directly or indirectly. Through photosynthesis plant transform solar and chemical energy derived from the soil into storable chemical energy as carbohydrates, proteins, fats and all cellulose. Excessive use of energy results in high unit cost of production, loss of net profits and market competitiveness. It is essential to convert the energy rapidly to common equivalents. Hence, the inclusion of crops like baby corn as diversification would reduce the energy production as they are poor converters of it, therefore suitable cropping systems needs to be designed, so that apart from higher productivity, it must be an efficient converter of energy. Keeping these things in view, the present investigation was conducted to find out the balanced fertilization for maximizing the productivity, quality, energy use efficiency and sustaining soil health in longer perspectives of pre-*kharif* baby corn under the irrigated ecosystem of Indo-Gangetic plains of Varanasi, India.

MATERIALS AND METHODS

Field experiment was conducted at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during the pre-*kharif* season of 2012 and 2013. The study farm is situated at 25°18'N latitude, 83°03'E longitude and at an altitude of 78.1 m above mean sea level. Experimental plot was sandy clay loam in texture (sand: 45.77%, slit: 30.41% and clay: 28.82%) having pH (7.43 and 7.44). It was moderately fertile being low in organic carbon (0.32 and 0.34%). The available N, P, K, S and Zn was 190.37, 18.81, 181.75 and 18.3 kg/ha and 0.50 ppm in 1st year and 193.57, 19.07, 183.95, 19.1 kg/ha and 0.52 ppm in 2nd year, respectively. Experiment was laid out at the same site during both the years in split plot design with three replications, keeping fertility levels (100 and 125% of RDF) and sulphur levels (0, 25 and 50 kg S/ha) in main-plots and zinc levels (0, 5 and 10 kg Zn/ha) in sub-plots. Crop was sown on 2nd May and 17 April during 2012 and 2013, respectively using seed rate of 40 kg/ha by opening a deep furrow of 5 cm at a spacing of 40×20cm. Baby corn hybrid, HM4 is a medium height plant type, lodging resistant, prolific and responsive to the high dose of fertilizers and remains green even after the picking of baby cobs. Minimum and maximum temperature ranged from 22.1 and 43.3^{o}C in 1st year and 20.1 and 40.9^{o}C during 2nd year, respectively. Crop received the rainfall of 166.6 mm in 2012 and 16.9 mm during 2013, respectively. Recommended doses of fertilizers (100% RDF: 150, 75, 60 kg NPK/ha) were applied as per the treatment through urea, di-ammoinium phosphate (DAP), muriate of potash (MOP) and for levels of S and Zn, elemental S and zinc oxide (ZnO) were used as a source, respectively. Full dose of P, K, S and Zn and half dose of N were applied as basal and remaining half doses of N was top dressed in two equal splits at knee high and tassel emergence stage. Application of atrazine @ 1.5 kg *a.i.*/ha was applied to control the initial weed flushes followed by hand weeding with hand hoe at 25 days after sowing (DAS). Detasseling was done immediately after the appearance of tassel to avoid the pollination and fertilization and finally gets the good quality of baby corn. Furad on @ 5 kg *a.i.*/ha was applied to check the attack of shoot borers at 20 DAS. Crop was harvested on 2 July and 17 April during 2012 and 2013, respectively. Baby cobs were harvested at 2-3 days after silk emergence and these cobs were counted, weighted thereafter husk and silk were removed and baby cobs and corn yield were recorded and expressed in tonnes/ha. The fresh baby corn and husk were sun dried and subjected to oven-dried at 65±5°C for 72 hr. Dried samples were ground in a Wiley mill, passed through 40-mesh sieve. The nutrients like NPKS and Zn content in plant samples were estimated with the standard methods as advocated by Linder (1944), Jackson (1973), Chesnin and Yien (1950), Lindsay and Norvell (1978), respectively. The crude protein content in baby corn and green husk was estimated by multiplying N content with the 6.25 coefficient factors (Humpshire 1956). Analysis of energy coefficient of baby corn was carried out based on the energy equivalents available for various inputs (Devasenapathy *et al*. 2009). Energy ratio of output-inputs was determined by the calculating of energy equivalent yields and energy consumed in the production. Human, machinery, fuel, seed, manure, fertilizer and pesticide consumption and yields values of crops have been included for calculating the energy use efficiency. Data pertaining to the each characters of the experimental crop were analyzed statistically by applying the standard techniques and significance of treatment differences were judged by the F-test. To evaluate the significant difference

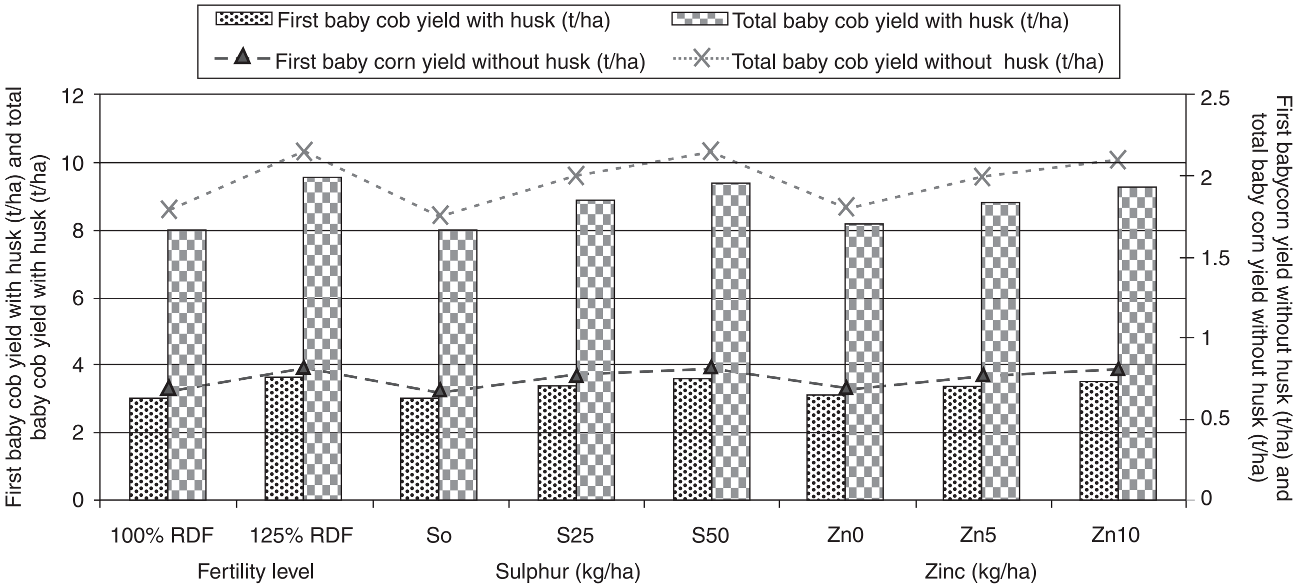

Fig 1 Effect of NKPS and Zn fertilization on yields and economics of baby corn (Pooled data of 2 years)

between the two treatment means, critical difference at 5% level was worked out (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Effect of fertility levels

Pooled data showed that the different levels of fertility significantly influenced the yields of baby cob and baby corn (Fig 1). Application of 125% RDF gave the highest yields of first baby cob with husk (3.65 tonnes/ha), total baby cob with husk (9.55 tonnes/ha), first baby corn without husk (0.82 tonnes/ha), total baby corn without husk (2.15 tonnes/ha),which were noted the significantly superior over 100% RDF. This treatment increases the yields of first baby cob with husk, total baby cob with husk, first baby corn without husk and total baby corn without husk by 20.1, 19.8, 18.8 and 20.1%, respectively over the 100% RDF. This might be due to the N being a major constituent of chlorophyll, amino acids and protein, P being the component of energy compounds, viz. ATP, NADP and K serving as an activator or cofactor for various enzymes involved in the photosynthesis and CO_2 fixation could have promoted the satisfactory plant growth, photosynthetic surface and yield structures. Significant increase in baby cob and corn yield due to the adequate and balanced supply of nutrition at higher fertility level influences the yield attributes and indirectly *via* increase in plant growth and possibly as a result of higher uptake of nutrients and finally into the crop yields. The results were in the close agreements with the findings of Kumar and Bohra (2014) in baby corn.

Application of different levels of fertility significantly affects the nutrient (NPKSZn) and protein content in baby corn and green husk (Table 1). The higher nutrient contents, *i.e.* 2.20, 0.44, 1.42% NKS in baby corn and 1.7, 0.26, 1.04% NPK in green husk were recorded with the application of 125% RDF, which was noted significantly superior over the 100% RDF and it showed the increase of 7.3, 5.1, 6.9% in baby corn and 11.1, 5.6, 6.5% in green husk over the 100% RDF, respectively. Whereas, the higher Zn content in baby corn and green husk was recorded with the application of 100% RDF. Singh *et al*. (2010) reported that the NPK and Zn contents in baby corn increased with the increasing level of fertility and the maximum values of these nutrients were recorded with application of the highest fertility levels of 160: 80: 50.33: 1.0 kg NPKZnha^{-1}.Similarly, the higher protein content in baby corn and green husk was recorded with application of 125% RDF and it showed the increase of 10.9 and 11.1% over the 100% RDF. Nitrogen, being the principle constituent of protein might have substantially increased the protein contents of baby corn and green husk due to the increased uptake of nitrogen. Thus, the better physiological and bio-chemical activity of baby corn with adequate and balanced nutrient supply might have enhanced protein content was confirmed by Singh *et al*. (2010).

Effect of sulphur

The yields of baby cob and baby corn significantly increased with application of sulphur (Fig 1).The maximum yields of first baby cob with husk (3.59 tonnes/ha), total baby cob with husk (9.38 tonnes/ha), first baby corn without husk (0.82 tonnes/ha) and total baby corn without husk (2.15 tonnes/ha) were recorded,where the S was applied @ 50 kg/ha but it was noted statistically at par with 25 kg/ha. This treatment increase the yield of first baby cob with husk, total baby cob with husk, first baby corn without husk and total baby corn without husk by 17.7, 17.1, 22.4 and 22.6%, respectively over the control. This could be favourable effect of sulphur application on yield attributes. The results were in the close conformity on maize with findings of Shivran *et al*. (2013) and Jeet *et al*. (2014).

Application of S increased the nutrient contents of NPKSZn and protein content in baby corn and green husk

Table 1 Effect of NKPS and Zn fertilization on nutrient content (%) of baby corn and green husk on dry weight basis (Pooled data of 2 years)

Treatment	Baby corn						Green husk					
	N	P	K	S	Zn (ppm)	Protein	N	P	K	S	Zn (ppm)	Protein
Fertility level												
100% RDF	2.050	0.433	1.354	0.159	34.745	12.815	1.535	0.248	1.033	0.116	43.395	9.605
125% RDF	2.200	0.440	1.423	0.170	32.330	14.215	1.705	0.264	1.074	0.125	41.615	10.670
CD (P=0.05)	0.085	NS	0.059	0.009	1.165	0.565	0.080	0.012	NS	NS	1.560	0.490
Sulphur (kg/ha)												
S_0	1.925	0.414	1.297	0.153	31.485	12.270	1.475	0.241	0.994	0.110	39.975	9.195
S_{25}	2.185	0.442	1.401	0.166	33.885	13.905	1.670	0.258	1.060	0.123	42.880	10.430
S_{50}	2.260	0.453	1.467	0.174	35.240	14.365	1.725	0.270	1.105	0.127	44.660	10.780
CD (P=0.05)	0.110	0.025	0.072	0.011	1.430	0.690	0.100	0.015	0.049	0.013	1.910	0.600
Zinc (kg/ha)												
Zn_0	1.965	0.421	1.315	0.156	31.900	12.510	1.500	0.244	1.003	0.111	40.505	9.365
Zn_5	2.190	0.441	1.406	0.166	34.015	13.925	1.670	0.259	1.067	0.121	43.045	10.465
Zn_{10}	2.220	0.448	1.444	0.171	34.695	14.110	1.695	0.266	1.091	0.127	43.965	10.585
CD (P=0.05)	0.085	0.019	0.050	0.008	1.035	0.535	0.065	0.011	0.035	0.009	1.295	0.405

over the control (Table 1). Significantly higher nutrient contents, *i.e*. NPKSZn were recorded with application of 50 kg S/ha, which was statistically similar with 25 kg S applied/ha. Increase of these nutrients to the tunes of 17.4, 9.4, 13.1, 13.7, 11.9 % in baby corn and 16.9, 12, 11.2, 15.5, 11.7% in green husk, respectively over the control, in case of treatment, where the 50 kg S/ha was applied. Similarly, the maximum protein content in baby corn and green husk were observed in 50 kg S/ha, but it was being at par with 25 kg S/ha and significantly higher than the control.This might be due to the favourable effect of sulphur on growth and yield attributes and enhancing the nutrient content in different plant parts. Kumar *et al*. (2015) also reported similar results in baby corn.

Effect of Zn

Application of increasing doses of Zn increases the yields of baby cob and baby corn significantly as compared to the control (Fig 1). The highest yields of first baby cob with husk (3.55 tonnes/ha), total baby cob with husk (9.24 tonnes/ha), first baby corn (0.81 tonnes/ha) and total baby corn (2.10 tonnes/ha) were associated the higher levels of zinc fertilization (10 kg Zn/ha) but being on par with 5 kg Zn/ha. This treatment showed to increase these attributes to the tunes of 14.5, 12.8, 17.4 and 16%, respectively over the control. Increase in yields of baby cob and baby corn due to Zn application might be due to fact that Zn plays an important role in the biosynthesis of IAA and initiation of primordial for the reproductive part and result of favorable effects of zinc on metabolic reaction within the plant system. The results were in close the conformity with findings of Keram *et al*. (2012).

Increasing levels of Zn application upto 10 kg/ha increased nutrient, i.e. NPKSZn and protein content in baby corn and green husk (Table 1). However, application of increasing levels of Zn (10 kg Zn/ha) significantly increased the NPKSZn content by 12.9, 6.4, 9.8, 9.6, 8.7% in baby corn and 13, 9, 8.8, 14.4, 8.5% in green husk, respectively butit was noted statistically at par with 5 kg Zn/ha. Dewal and Pareek (2004) opined that wheat fertilized with Zn improved the nutritional environment of the rhizospheres, which resulted in higher uptake of nutrients by the crop and this caused pronounced metabolic and photosynthetic activity in plant leading to the higher yield. Similarly, protein content in baby corn and green husk with increased application of 10 kg Zn/ha and it showed 12.8 and 13% increases over control. This could be due to increased conversion of N to protein compounds and build-up of free amino acids and amides in the plant with Zn application (Mehandi *et al*. 2012).

Energetics

Results revealed that the energy input increased with increasing levels of fertility (Table 2). Pooled data showed that application of 125% RDF consumed higher energy input (20.71×10^3 MJ/ha) and the lowest with 100% RDF (17.83×10^3 MJ/ha). Further, higher energy inputs was consumed with 50 kg S applied/ha (18.33×10^3 MJ/ha) followed by 25 kg S/ha. Similar trend were followed in case of zinc application, where 10 kg Zn applied/ha recorded to consume the highest energy inputs (17.91×10^3 MJ/ha) compared to rest of treatment. However, the consumption of energy inputs were followed in the order of $Zn_{10}>Zn_5>Zn_0$. This might be due to more inputs especially the fertilizers were consumed with the respective treatment (Bohra and Kumar 2014).

Similarly, the highest energy returns (226.98×10^3 MJ/ha) and net energy returns (205.98×10^3 MJ/ha) were

Table 2 Energy use efficiency of baby corn as influenced by NKPS and Zn fertilization (Pooled data of 2 years)

Treatment	Energy input (×10[3] MJ/ha)	Energy returns (×10[3] MJ/ha)	Net energy returns (×10[3] MJ/ha)	Energy use efficiency	Energy productivity (kg/MJ)
Fertility level					
100% RDF	17.83	189.27	171.15	10.44	0.439
125% RDF	20.71	226.98	205.98	10.80	0.454
CD (P=0.05)	-	125.88	125.88	0.62	0.027
Sulphur (kg/ha)					
S_0	17.83	190.41	171.10	9.85	0.414
S_{25}	18.09	210.85	191.29	10.76	0.453
S_{50}	18.33	223.12	203.31	11.25	0.473
CD (P=0.05)	-	15.42	15.42	0.76	0.033
Zinc (kg/ha)					
Zn_0	17.83	194.72	175.20	9.96	0.419
Zn_5	17.87	209.97	190.41	10.71	0.451
Zn_{10}	17.91	219.69	200.09	11.19	0.471
CD (P=0.05)	-	11.73	11.73	0.59	0.025

recorded with application of 125% RDF and comparatively lower with 100% RDF (189.27 and 171.15×10^3 MJ/ha), respectively (Table 2). Among different levels of sulphur, application of 50 kg S/ha recorded the highest energy returns (223.12×10^3 MJ/ha) and net energy returns (203.31×10^3 MJ/ha) but it was noted statically at par with 25 kg S/ha and significantly superior over the control. Among Zn levels, the highest energy returns (219.69×10^3 MJ/ha) and net energy returns (200.09×10^3 MJ/ha) were obtained with fertilization @10 kg Zn/ha followed by 5 kg Zn/ha.

Maximum energy use efficiency (10.80), energy productivity (0.454 kg/MJ), energy profitability (9.80) and human energy profitability (65.20) were found with application of 125% RDF level and the minimum with 100% RDF (Tables 2 & 3). Similarly, higher energy use efficiency (11.25), energy productivity (0.473 kgMJ^{-1}), energy profitability (10.25) and human energy profitability (64.09) were recorded with the application of 50 kg S/ha, which was noted comparable with 25 kg S/ha (10.76, 0.453 kg/MJ, 9.76 and 60.57, respectively). Similar trends were followed in case of Zn levels also. The highest values of these parameters were recorded with application of 10 kg Zn/ha followed by 5 kg Zn/ha. The similar findings were reported by Bohra and Kumar (2014).

Application of 125% RDF recorded the highest energy output efficiency of 3.78×10^3 MJ/ha day and energy intensity

Table 3 Energetics attributes of baby corn as influenced by NKPS and Zn fertilization (Pooled data of 2 years)

Treatment	Energy intensiveness (MJ/₹)	Energy intensity (MJ/kg)	Energy output efficiency (×10[3] MJ/ha day)	Specific energy (×10[3] MJ/t)	Energy intensity in physical terms (MJ/kg)	Energy intensity in economic terms (MJ/₹)	Human energy profitability	Energy profitability
Fertility level								
100% RDF	0.315	2.30	3.16	5.55	0.537	3.29	54.37	9.44
125% RDF	0.354	2.22	3.78	5.53	0.518	3.82	65.20	9.80
CD (P=0.05)	-	0.14	0.21	0.18	0.039	0.21	3.62	0.62
Sulphur (kg/ha)			0.00	0.00				
S_0	0.340	2.42	3.17	5.55	0.568	3.34	54.69	8.85
S_{25}	0.335	2.23	3.51	5.53	0.519	3.60	60.57	9.76
S_{50}	0.330	2.13	3.72	5.53	0.496	3.71	64.09	10.25
CD (P=0.05)	-	0.17	0.26	0.22	0.047	0.26	4.43	0.76
Zinc (kg/ha)								
Zn_0	0.341	2.41	3.25	5.54	0.563	3.40	55.93	8.96
Zn_5	0.335	2.24	3.50	5.54	0.523	3.59	60.31	9.71
Zn_{10}	0.328	2.13	3.66	5.53	0.497	3.67	63.11	10.19
CD (P=0.05)	-	0.12	0.20	0.10	0.033	0.20	3.37	0.59

Table 4 Effect of fertility, S and Zn levels on S and Zn balance in soil after harvest of baby corn

Treatment	S uptake by crop (C) (kg/ha)		Soil S after harvest (D) (kg/ha)		S balance (A+B) - (C+D) (kg/ha)		Zn uptake by crop (C) (kg/ha)		Soil Zn after harvest (D) (kg/ha)		Zn balance (A+B)- (C+D) (kg/ha)	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Fertility level												
100% RDF	5.90	6.28	16.28	18.42	-4.43	-6.44	0.353	0.388	0.511	0.524	-0.32	-0.36
125% RDF	7.57	8.16	16.94	18.94	12.00	-14.53	0.441	0.486	0.521	0.539	-0.50	-0.55
CD (P=0.05)	0.65	0.60	NS	NS			0.033	0.030	NS	NS		
Sulphur (kg/ha)												
S_0	5.69	6.05	16.11	18.33	-3.28	-5.15	0.339	0.376	0.509	0.522	-0.23	-0.25
S_{25}	6.89	7.41	16.64	18.64	15.90	13.84	0.405	0.446	0.518	0.528	-0.44	-0.49
S_{50}	7.63	8.21	17.09	19.09	37.73	34.85	0.447	0.489	0.522	0.544	-0.55	-0.62
CD (P=0.05)	0.80	0.74	NS	NS			0.041	0.037	NS	NS		
Zinc (kg/ha)												
Zn_0	5.90	6.33	16.11	18.33	-3.96	-5.84	0.351	0.388	0.509	0.522	-0.21	-0.23
Zn_5	6.88	7.37	16.62	18.62	-9.14	-11.49	0.406	0.446	0.517	0.527	4.55	4.50
Zn_{10}	7.43	7.97	17.10	19.10	11.54	-14.12	0.434	0.478	0.523	0.544	9.44	9.38
CD (P=0.05)	0.53	0.54	NS	NS			0.027	0.033	NS	NS		

Initial status (A) S: 18.3 and 19.1 kg/ha during 2012 and 2013, respectively, initial status Zn: 0.50 and 0.52, during 2012 and 2013 respectively and B: amount of added nutrient S (25 and 50 kg S/ha) and Zn (5 and 10 kg Zn/ha)

in economics terms of 3.82 MJ/ha and the lowest with100% RDF (Table 3). While the highest energy intensity of 2.30 MJ/kg and energy intensity in physical terms 0.555 MJ/kg were registered with the fertilization of 100% RDF and the lowest energy intensity of 2.22 MJ/kg and energy intensity in physical terms 0.531 MJ/kg with 125% RDF (Table 3). Similarly, application of 125% RDF registered the maximum energy intensity of 3.72×10^3 MJ/ha^{-1}day^{-1}and energy intensity in physical terms of 3.71 MJ/ha whereas the minimum with 100% RDF. While, the maximum energy intensity of 2.42 MJ/kg and energy intensity in physical terms 0.568 MJ/kg were recorded with the control followed by 25 and 50 kg S/ha. Further, the energy output efficiency and energy intensity in economics terms were increased with application of increasing levels of S upto 50 kg/ha while the energy intensity and energy intensity in physical terms decreases with increasing level of sulphur fertilization (Table 3). Similar trends were also followed in case of zinc application. Similar findings were reported by Bohra and Kumar (2014).

Energy intensiveness and specific energy were influenced by various fertility levels, sulphur and zinc fertilization (Table 3).The highest energy intensiveness of 0.354 MJ/₹ and specific energy of 5.53×10^3 MJ/t were registered with application of 125% RDF and the lowest with 100% RDF (0.315 MJ/₹ and 5.54×10^3 MJ/t), respectively. Further, application of 50 kg S/ha gave the lowest values of energy intensiveness of 0.33 MJ/₹ and specific energy of 5.53×10^3 MJ/t, whereas the highest values of these attributes were associated with the control. Similarly, maximum value of energy intensiveness and specific energy (0.341 MJ/₹ and 5.54×10^3 MJ/t) were recorded under the control followed by 5 kg Zn/ha (0.335 MJ/₹ and 5.54×10^3 MJ/tand the lowest with 10 kg Zn/ha (0.328 MJ/₹ and 5.53×10^3 MJ/t). Similar findings were reported by Bohra and Kumar (2014) in their field study.

Soil balance sheet

Post-harvest fertility status of the soil was found to be non-significant due to varying fertility levels, S and Zn fertilization during both the year (Table 4). Whereas, the maximum values of these nutrients were recorded with application of 125% RDF, 50 kg S and 10 kg Zn/ha. The lowest actual loss and balance of S and Zn in the soil were recorded with the application of 100% RDF and the maximum with 125% RDF during both the years. Similarly, positive actual gain of the respective nutrients were recorded in plots, where no S and Zn applied, whereas, the maximum actual loss of both the nutrients were noted under 50 kg S and 10 kg Zn/ha followed by in 25 kg/S and 5 kg Zn/ha, respectively. The maximum S balance was recorded with 50 kg S/ha followed by 25 kg S/ha and the lowest with control. Similarly, the maximum Zn balance was recorded with 10 kg Zn/ha followed by in 5 kg Zn/ha and the lowest with the control during both the years. Post-harvest soil fertility status with respect to available S and Zn were found to be improved with each successive level of S and Zn application but it did not reach at significant level. The present results were in close conformity with those reported by Keerthi *et al*. (2013).

Hence, it may be concluded that to maximize the production, quality, energy use efficiency and sustaining soil health of baby corn in longer perspectives, crops should be fertilized with 125% RDF, 50 kg S along with 10 kg Zn/haunder the irrigated ecosystem of Varanasi, India.

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